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SENSORY METROLOGY: WHEN EMOTIONS AND EXPERIENCES CONTRIBUTE TO DESIGN.

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ABSTRACT
The analysis of users' experience is indispensable in order to catch the subjectivity. For this reason the industrial designer needs to take into account these new qualitative properties, and translate them in a concrete way during the creative process. Firstly the sensory information acquired need to be coached by the material experience. The user is able to construct his relation with the product primarily interfacing himself with the skin of the object by touch and sight, and after that explore its functionality. The work aims to improve the development of emotional and feeling investigation by the use of an holistic approach that take into account all the product's aspects. To realise this investigation has been chosen to apply the technique offered by Sensory Metrology discipline and two methods derived from the Classical Sensory Evaluation. In this paper the test experiences done in order to read users' subjectivity have been described. The different proofs have been structured in three different moments. Results have shown the possibility to use the sensorial sphere as a constructive matter to achieve user's affection to the products always from an holistic point of view.

Keywords: human behaviour in design, experience design, emotional design, sensory metrology, texture

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1 INTRODUCTION

The new era of industrial design could be seen as a synthesis of the contemporary economies where the product design focuses on the quality involved by product and user relationship. The actual scenario pays attention to the new contexts of use that have become the key elements of the innovation process of design creation. All these contexts involve sensory elements and profound analysis of users behavior. Sensations have become the starting point from which the relation between owner/user and product gets structure. This relation is based on subjective and qualitative aspects which normally are not measurable. In particular for the industrial sector these qualitative aspects belong to the external surface of products and consequently to the material which they are made of. Furthermore, the exchange of senses between objects and users have to be defined as a multi sensorial exchange due to the several combinations of senses involved. Humans are used to experience the surrounding world with a complete sensory implication. Thus, the senses cannot be isolated and separately investigated if the objective is the real human behavior analysis. The present work aims to promote the use of the holistic approach in the sensory investigation. Starting from the analysis of the Classical Sensory Evaluation and its declination in Sensory Metrology, has been tried to insert this new approach. The effectiveness of the multi sensory construction of the Sensory Metrology tool has been tested to analyze industrial products. Moreover a new way to use the classical methods of correspondence analysis and sorting test have been experimented in order to let them become more suitable for the industrial sectors. The research and tests process have been explained in all the details by showing and describing the different kind of proofs to which users involved in the direct analysis have been subjected. The different proofs have divided the work in three main steps, subdivided in other small sessions in turn. Results have shown the possibility to start to think about the sensorial sphere as a constructive matter to achieve user's attention and affection to the products. Simultaneously the possibility to develop new method suitable for quick and practical application during the industrial creative engineering design process has been tested.

2 SENSORY ANALYSIS' INNOVATIONS

Alongside this brief introduction on the aims of the work, the method which has been used in order to analyze the qualitative aspects of products needs to be explained. The reference discipline that has been selected for the investigation is the Sensory Evaluation Analysis, and in particular the innovative changes that have brought to this analysis' context the introduction of new sectors of application. The Sensory Evaluation Analysis has been introduced in the market/industrial sector starting from the 1950. It has been defined as a set of techniques and practical activities able to measure and translate human's perception in a consistent way. Its purpose is the complexity reduction of the subjective sensory variables derived by the contact with industrial products, in a simple and measureable way (Bassereau, 1995). This kind of method is one of the major modalities used by Emotional Marketing and Kansei Engineering (Bandini Buti, 2008) to achieve user's feelings in specific fields. One interesting element that has to be pointed out from the use of Sensory Evaluation Analysis, is the possibility to analyze user's behavior. By keeping as reference what happens during Sensory Evaluation Analysis planned in food and cosmetic industry, from the 1990 a new way to investigate the properties of other industrial products starting from the same typologies of techniques and proofs settings had been designed. Before talking about this innovation is better to briefly describe the main features of interest for the work related to the classical Sensory Evaluation Analysis' context.

2.1 Main Features

2.1.1 Test typologies

Classical Sensory Evaluation methods are measurements techniques used in factory fields and research centers. The different techniques of analysis are classified and chosen by taking as reference the judgments and answers needed for the study. There are two macro-groups: from one side categorical and analytical evidence to discriminate against products, qualify and quantify sensory stimulus; on the other side hedonic test to assess the preference or aversion.

2.1.2 Users selection

The real actor of the analysis is the user. For tests provided for the classical Sensory Evaluation Analysis the user is a single part of an entire group called panel. The single user is defined as panelist. Classical Sensory Evaluation defines this figure in two way depends on the chosen test typology. The panelist could be trained or naïve. The naïve one is a spontaneous panelist that provides answers to the test by using only his experiences, knowledge, opinions, skills and impressions. The trained one is part of the entire pre-defined group of panel, trained to recognize and express what he feels by the use of specific terminology and behavior. The words that he uses to express what he feels are called descriptors. The training program need long time preparation, like six or more months. At the end of the training all the members of the panel reach the same level of preparation and skills. This step determines a sort of agreement between them useful to starting the sensory experience from the same level and determines the creation of a common Sensory Profile (Depledt, 2009).

2.1.3 Statistical results elaboration

The data elaboration is based on statistical treatments in order to collect and use each singular panelist's contribution. The analysis of products could use one dimension or multi dimension approach properly defined for the different typologies of tests (Depledt, 2009).

2.1.4 Standardization

The Sensory Evaluation Analysis has been developed and considered as a scientific discipline with its own standardization. The first standardization starts in 1968 with the first definition of Sensory Analysis. After that, all the rules concerning the topic have been described in the standard entity of the different European states. The more developed are: the French one (AFNOR) with the index reference V09 and the International one (ISO) that from the 1992 have started to define a sensory vocabulary and subsequently during the 2005 the different investigative methods (D'Olivo, 2012).

2.1.5 Stimuli

The Sensory Evaluation Analysis is a monadic investigation related to homogeneous products. This means that all the products that are tested by the panel are analyzable by the use of one sense per time (i.e. fruit juice tested only by taste).

2.2 A derived discipline: Sensory Metrology and the Napping® tool

From the 1990 the Sensory Evaluation Analysis has been adapted and updated with the introduction of a new discipline able to catch the real needs of new industrial sectors. This discipline called Sensory Metrology, actually is trying to investigate the subjective sensory variables like the classical evaluation used to, but with a holistic approach, then considering the product in all its parts. This discipline, indeed, focuses its doctrine in the analysis of non homogeneous products like the industrial products derived from automotive, furniture sectors and so on. With this kind of objects the perceived sensations cannot be analyzed in isolation due to the contact with the user is complete and subjective.
Furthermore, considering the technical side, differently from the classical Sensory Analysis it is necessary to outline a "product space" with the aim of translate a number of selected object/stimuli into measurable samples. The products are selected according to certain surface features, like roughness, color, or other kind of peculiarities that could be caught by senses. The panelist figure definition follows the same rules provided for the Sensory Evaluation Analysis distinct in trained and naïve. Also the Sensory Metrology tests' results are given by statistical elaboration. As happens for the classical discipline, also for the Sensory Metrology has been done a standardization starting from the 2003 (AFNOR/V09B), in which have been described the "sensory characterization of materials" by the use of touch and sight.

3 TESTING THE APPLICATION ON INDUSTRIAL DESIGN FEATURES

The work is based on testing the value of human behavior and in particular on analyzing the subjective responses given by the users when he came in contact with product. In order to give sensorial information about industrial products it is necessary to define which aspect has to be investigated. As regard industrial products one of the main important features is the surface. The surface is the place where the relevant actions happen (Gibson, 1983), therefore, becomes the area of human activity and chemical/physical reactions. The surface is made of material and that's the reason why the material

needs to be investigated: as something that gives structure to the product and as a vehicle of emotions and experience. The structured experience, described in the paper, has been organized in a holistic approach according to the fact that we want to analyze heterogeneous products.
From one side has been tested how much Sensory Metrology (as holistic method) could help in order to collect information about the sensory properties of materials by exploiting the users' perception. From the other side has been chosen to take two testing methods belonging to Classical Sensory Evaluation and to use them with the holistic approach in order observe the results. Furthermore, for all the tests done during the experiences has been chosen to exploit the figure of untrained panelist. In fact this kind of panelist could be tested in his subjective responses. In this way the same situation that the user usually has when starts a contact with the product for the first time could be recreated, in order to achieve useful feedbacks for industrial production details. Moreover, this became an indirect proof to test if the naïve panel could become useful instead of the trained one in the collection of sensory descriptors. Avoiding the long time training, expensive environments' organization, examiners' preparation and so on.

3.1 Test choices and common set up

The work has been structured in three different moments according with the use of different methods related to Sensory Metrology or Classical Sensory Evaluation. Each method has been taken from the technical literature related to the study of Sensory Metrology and Sensory Evaluation Analysis. The latter one has been revised and managed in order to let it become more suitable for a multi sensorial analysis. In this way has been investigated the possibility to develop new tools for the Design context. The chosen methods have been:

- the Napping® method, typical of Sensory Metrology
- the Correspondence proof from the Classical Sensory Evaluation
- the Sorting test from the Classical Sensory Evaluation

According with the rules of Sensory Metrology a specific "product space" have been defined by choosing a precise set of materials and precise number of panelists per panel. Before starting each proof the user has been informed about the rules with written instructions and has been subjected to a brief survey. All the resulting data have been collected with written schemes, videos and pictures. After that, a statistical elaboration has been made in Excel environment and with the use of French software Sensominer® (Pagès, 2004). The data elaboration has been showed interesting and comparable results.

3.1.1 Experiment 1 - Napping® test

The Napping® test it is a descriptive method in which the user has to move the samples over a tablecloth space called "nappe" (in French) (Pagès, 2005). During the test the panelist has to define a personal space disposition according to his sensations. In this way, more the samples are similar more they will be closer. Otherwise, if the perception is completely different the samples will be moved in opposite side. Furthermore, at the end of the disposition the panelists have been asked to express with words their perceived feelings. To develop the test has been chosen a group of untrained panelist with an aged between 20 and 50 years old (for easiness in verbal explanation of what they feel). In order to set up the right samples for the test, 12 different materials with interesting surface have been chosen (Figure 1). They have been chosen for their surface peculiarity such as: mesh, printed textures with different roughness level, temperature, softness and brightness. For this reason the range of chosen materials has been comprehensive of fabrics, metals and composites (metals mixed with polymers).
For the test, all the materials had to be shown with the same shape conditions, so a squared sample holder made of cardboard and nonwoven textile with a squared containment frame has been developed. The ideal samples' size (smaller than the sample holder) that has been selected for the analysis is 5 by 5 cm. All the samples have been named and marked with an alphabetical code in order to facilitate the data collection.

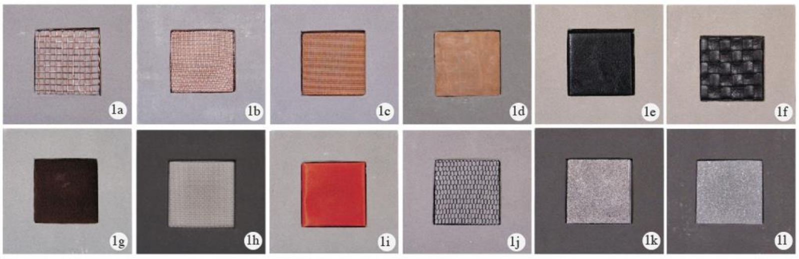


Figure 1. Samples for the Napping® test: 1a) A - large copper mesh, 1b) B - medium copper mesh, 1c) C - fine copper mesh, 1d) D - copper-tin fabric, 1e) E -fake smooth leather, 1f) F - fake mesh leather, 1g) G - velvet, 1h) H - cotton mesh fabric, 1i) I - taffeta, 1j) J - nylon mesh, 1k) K - aluminum S460, 1l) L - aluminum NK F24

The Napping® test has been still divided in three sessions in order to check the potentiality offered by the multi sensorial approach:

- haptic sense (Figure 2): in the session, each user has been blindfolded and has moved the samples according only to his haptic perception. After the samples organization on the table has been asked to the user to describe with a word the perception for each sample;
- sight sense and haptic sense together (Figure 3): in the session, each user has been let free to see and touch the samples in order to define his samples preferred position. After the samples organization on the table has been asked to the user to describe with a word the perception for each sample;
- sight sense and touch sense at the same time and two descriptors given to the users as Brightness and Roughness (Figure 4): in the session, each user has been let free to see and touch the samples. In this case has been added the constraint of two given descriptors as usually happens for the trained panel's program. The two descriptors have characterized the two main axes, Roughness for the X and Brightness for the Y.

At the end of the experiments all the data have been collected by taking as references the tablecloth schemes. The data elaboration has been made with the Sensominer® software in R environment for statistical treatments (Pagès, 2004).

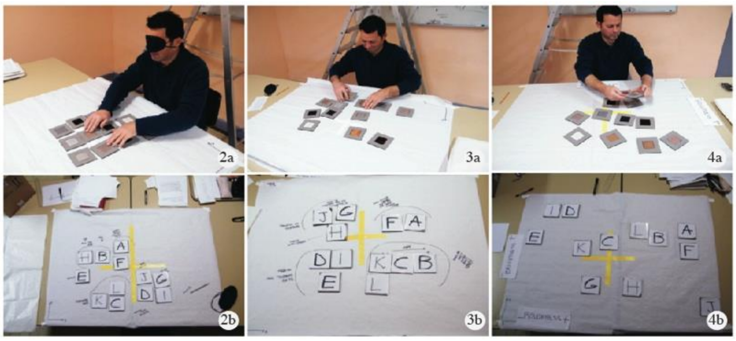


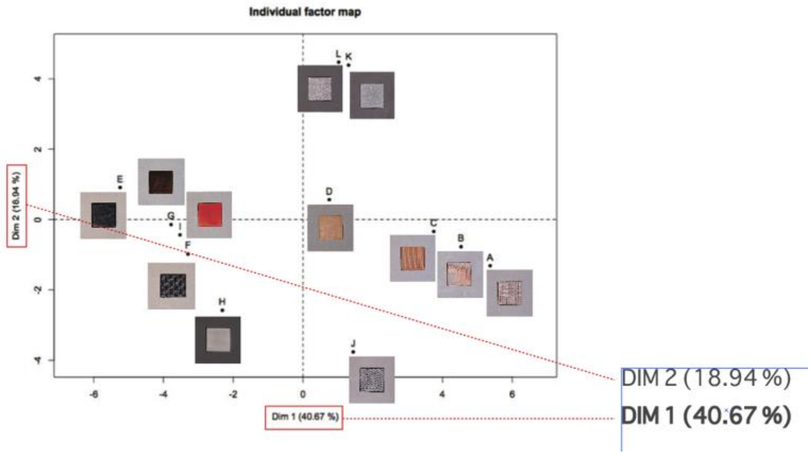
Figure 2. Napping® test by touch: 2a) disposition, 2b) tablecloth

Figure 3. Napping® test by touch and sight: 2a) disposition, 2b) tablecloth

Figure 4. Napping® test by touch and sight + descriptors: 2a) disposition, 2b) tablecloth

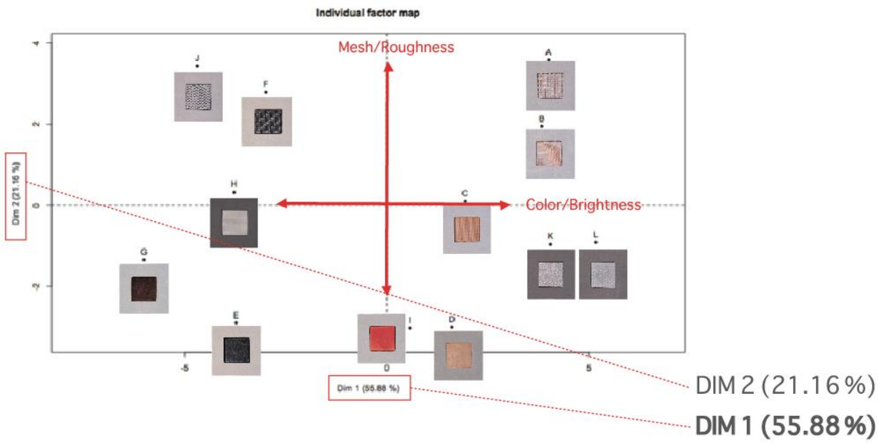
For this kind of test the statistical treatment is based on the use of MFA (Multiple Factorial Analysis) that for all the data collected from the proof allows to calculate a common factor that brings the values at the same level of relevance (Pagès, 2004). Within the several kinds of graphs obtained from the statistical treatment the attention have been focused on the use of IFM (Individual Factors Map). The IFM is used to show the average preferences disposition of the users in order to underline the distances between the samples. The first test has shown that the only use of touch to manage samples in a defined space is difficult and the users preferred to put the samples in line like in sorting. This is the demonstration that this kind of test is suitable only for a multi sensorial analysis. But the only use of touch constrains the users to pay more attention to the details of the surface and they are able to describe in a better way their feelings with a huge number of subjective descriptors. These descriptors become useful to understand how users used to describe particular materials by matching the samples with their feeling's definition. The second session gives demonstration that the use of a multi sensorial approach is the best way to classify perceptions and organize the samples positions. Between the panelists a good level of agreement has been found as regards the grouping of sensations and their definition. The second test permits a less number of collected descriptors because the users haven't focused over the touch perception, but their opinion is more biased by sight and light reflection over the surface. The % value reported on the graph (Graph 1) express the level of relevance given by the users to the dimension. In this particular example the main axis is the horizontal one and expresses the main dimension that the users have decided to "use" for the division of the samples; in fact according with the descriptors given the main poles are the presence or absence of mesh/texture and the color differentiation.

Graph 1. Results of the Napping® test by touch and sight – IFM



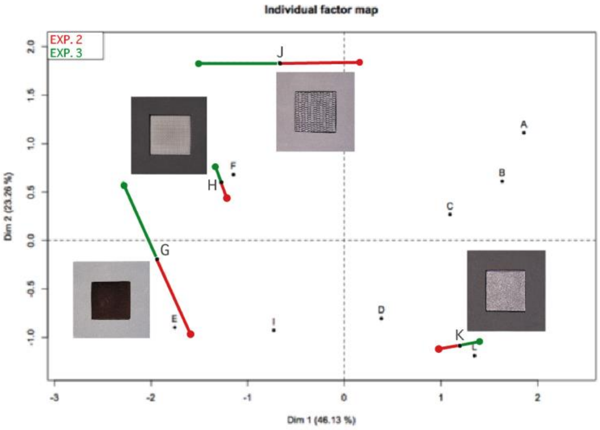
The third test (with the use only of descriptors) give similar results to the second one and this is the demonstration that the chosen descriptors (in the specific case brightness and roughness) are the main constraints used by the panelist too. In fact ROUGHNESS could be seen as the feeling translation generated by texture, and BRIGHTNESS otherwise the effect given by the light reflection over the surface is strictly linked with the surface color (Graph 2). But in this case the panel has been guided and the collection of description hasn't been possible.

Graph 2. Napping® test by touch and sight + descriptors - IFM



Finally, the comparison within the 2° and the 3° test is shown in Graph 3. The results are really similar in fact, the letters are referred to the samples with the same position between the 2° and the 3° test. Instead, few of them indicated with the colored lines are the samples that have been placed in different position within the 2° experiment. This difference concerns with the ambiguous nature of the samples, in fact some panelist have found difficult to describe those samples.

Graph 3. Comparison between the two sessions – IFM



3.1.2 Experiment 2 - Correspondence proof

This kind of proof has been ideated in order to understand if the panel is able to recognize the features that characterized the materials surface and how sight and touch work together in this case. The classical concept of correspondence proof usually suited for monadic products has been modified in a holistic way. For the proof has been selected a panel of new 8 untrained users, because they haven't been influenced by samples and questions used before. After that have been prepared new samples with squared shape 5 by 5 cm: 6 aluminum samples, 6 black resin samples and 1 copper sample. All the samples have been texturized with different abrasives (different for dimension and shape). The resin samples have been prepared like copies of metal samples, thanks to the use of silicone molds (Figure 5).

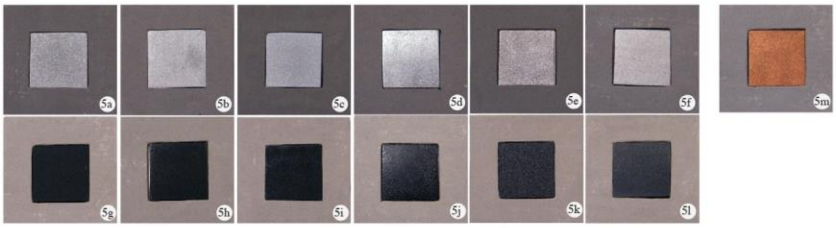


Figure 5. Samples for the correspondance proof: 5a) aluminium NK F10, 5b) aluminium NK F16, 5c) aluminium NK F24, 5d) aluminium S660, 5e) aluminium S460, 5f) aluminium S330, 5g) resin NK F10, 5h) resin NK F16, 5i) resin NK F24, 5j) resin S660, 5k) resin S460, 5l) resin S330, 5m) copper S330

An image of each single metal sample has been taken in order to construct a sort of render copy of real material. Thus, the 6 correspondent images of the 6 metal samples have been prepared. Other 2 images have been prepared by selecting one specific sample and adding luminance variation in the images (i.e. the Y coordinate value has been changed in the XYZ optical space) (Figure 6). All the images have been used in grey scale color.

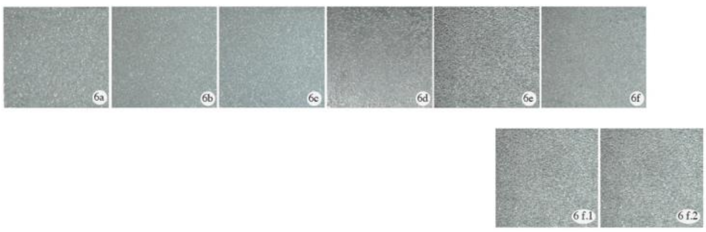


Figure 6. Images for monitor visualization: 6a) aluminum NK F10, 6b) aluminum NK F16, 6c) aluminum NK F24, 6d) aluminum S660, 6e) aluminum S460, 6f) aluminum S330, 6f.1) aluminum S460 Y-0.1, 6f.2) aluminum S460 Y-0.25

In a dedicated laboratory with stable conditions of light and instruments a monitor has been positioned. As concern the final disposition of perfect experimental environment, the monitor has been calibrated with the use of a spectrometer to accomplish the right RGB color definition. The 8 images have been uploaded in a slideshow presentation with black background and by showing only a magnification of 1 by 1 cm of the total surface of the samples. The color scale has been chosen as grey scale to avoid bias of perception over the black resin samples. Over the table with the monitor a piece of dark textile have been prepared where the samples, content in the sample holder, have been respectively covered and uncovered when necessary. In this kind of proof the users have been asked to compare in 8 different brief sessions of few minutes the samples with the images and link them between each other. The difficult point has been related to the use of the senses. In fact in 4 sessions the panelists have been free to use both sight and touch to compare the real samples with the images, in the remaining 4 only the touch for the samples and the sight for the images (in order to isolate the sensations) (Figure 7).

Figure 7. Correspondence proof: 7a) monitor calibration, 7b) session with showed samples, 7c) session with hidden samples

In this way the proofs have suggested interesting observations about correspondence between sight and touch and demonstration of sensory synesthesia. Furthermore has been analyzed how human perception tries to detect differences and references to recognize something. The data collection has been done by the use of an Excel chart and the insertion of the users' answers. The wrong answers have been written in red. After the data collection and the analysis of the recorded videos have been made some observations. For the test has been understood that the two main elements used by the panelist to discriminate the samples are: surface texture and texture's features. In second time the size of texture's regular/irregular elements lets the panelist discriminate between samples manufactured with abrasive with the same shape but different dimension. Another interesting observation has been done over the thermal perception of the samples. In fact, the mix of materials disorients users that during the session with the use of touch only have tried to call their personal experiences with similar perceptions in order to give the right answer. The last observation has been referred to the importance of sight and light reflection over the surface. The possibility to give a look to the real samples seems to be indispensable for the comparison between the scattering dynamic way wherewith the light reflects over the surface and the static impression gives by monitor image. Furthermore the light perception gives value to the designed texture emphasizing more or less its features. Thus, the importance of the multi sensorial approach has been validated again.

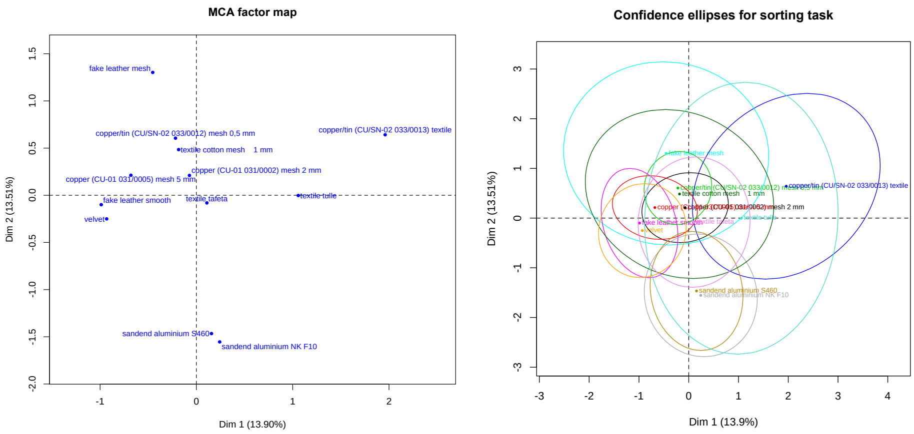
3.1.3 Experiment 3 - Sorting test (Consistency perception)

The third analysis is addressed to the evaluation of sensory consistency. As explained by studies reported to the surprise elicited by products, the incongruity perception is one of the major features that designers have to exploit to attract the consumer's attention. The sorting test used for the last part of the work is one of the Classical Sensory Evaluation methods but has been used in the holistic way (according with the aims of the work). By keeping as reference the same panel used during the first test and the same chosen samples has been prepared another experimental set. As first step a numerical scale has been created. Over a tablecloth, has been drawn a line with three points of division: 0, 5 and 10. The scale is indispensable to separate the samples perceived as inconsistent (0) from the ones perceived as consistent (10). The users have been invited to make again their perception analysis over the surface's samples and sort the 12 samples along the scales according to their sensory consistency (Figure 8).

Figure 8. Consistency test: 8a) samples investigation, 8b) sorting, 8c) consistency scale

The consistency refers to the correspondence between what the user are able to see and touch. If the two information are equal there is consistency, if are different is inconsistency. In this experiment the panelist's proper feelings are useful to define the level of this mismatch. In this final proof the data collection has been done by the creation of a graduate scale where the position of each samples have been inserted for each panelist according with the rules expressed before. After that a data elaboration has been made by the use of typical Classical Sensory Evaluation statistical treatments in order to create a MCA (Multiple Correspondence Analysis) graph and the confidence ellipses graph (Graph 4).

Graph 4. Results of the Consistency perception – Sorting test with the use of MCA factor map and confidence ellipses



From this data visualization and the recorded video analysis it has been possible to assess that the texture that characterize the material surface is the main element that is able to bias user's judgment. The texturing completely changes the perception of the surface, by capture shades of light and colors that construct new impressions. At the same time most of the samples positions have been linked to the experience that the user used to have with the particular material. The consistency has been constructed by panelists' memory. The more they are familiar with the material, the more they will feel it as recognizable and usual. The visualization of the MCA graph with the use of confidence ellipses shows which are the samples with the huge spreading area value. The samples with bigger ellipse area are the ones that are able to create disagreement between the use of sight and touch together. Those are the samples with a particular surface that is difficult to catch immediately and create more episodes of inconsistency. If the sample shows a small ellipse area it means that there is an agreement between the multi sensory perceptions and so they are consistent.

4 CONCLUSIONS

In the presented paper innovations on the Sensory Evaluation discipline have been described, and a different point of view with the introduction of the holistic approach has been done. The effective presence of sensory details over industrial product and their material has been demonstrated. These details have become a production necessity in the engineering design world. In this way the paper defines how it is possible to apply a holistic and fast approach to understand the main spontaneous direction taken by users during a product investigation and collect in a measurable way this information. Selection and definition of materials surfaces is not only driven by an engineering or technical logic but can be driven by the sensory effect conceived (Del Curto, 2008). Nowadays it is no longer sufficient to design good products or services, we all want to design experiences and generate pleasurable or exciting sensations (McDonagh et al., 2003). We are aware that the control of sensory variables is a necessary condition to give value and enrich perceptive and sensorial experiences. For this reason the matter as support of product's appearance needs technologies and industrial process links, in order to define new textures or surfaces for instances. Moreover, Sensory Metrology and the introduction of the multi sensorial investigation in the classical environment could bring new developments applicable for the Design and Engineering creative process. Furthermore the use of reference material samples instead of the entire products could became an interesting way to define a sort "sensation archive" related to specific materials/surfaces. In this way it is possible to declare that Sensory Evaluation and the innovative Sensory Metrology could be effectively introduced in the Design and Engineering environment, as already happen for Kansei Engineering, but with the possibility of a holistic point of view. This innovation could imply improvements: in the design engineering process timing due to the use of fast approach as Napping® and cost benefits with the possibility to use common users without preparation but with strong subjective potentialities.

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